PB-240 224

BLACKDUCK LAKE, BELTRAMI COUNTY, MINNESOTA

Pacific Northwest Environmental
Research Laboratory

Prepared for:

National Environmental Research Center
Minnesota Pollution Control Agency
Minnesota National Guard

November 1974

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during one year study of the lake and its tributaries are included in the report.

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REPORT

ON

BLACKDUCK LAKE

BELTRAMI COUNTY

MINNESOTA

EPA REGION V

WORKING PAPER No. 86

WITH THE COOPERATION OF THE

MINNESOTA POLLUTION CONTROL AGENCY

AND THE

MINNESOTA NATIONAL GUARD

NOVEMBER, 1974

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Minnesota Pollution Control Agency for professional involvement and to the Minnesota National Guard for conducting the tributary sampling phase of the Survey.

Grant J. Merritt, Director of the Minnesota Pollution Control Agency, John F. McGuire, Chief, and Joel G. Schilling, Biologist, of the Section of Surface and Groundwater, Division of Water Quality, provided invaluable lake documentation and counsel during the course of the Survey; and the staff of the Section of Municipal Works, Division of Water Quality, were most helpful in identifying point sources and soliciting municipal participation in the Survey.

Major General Chester J. Moeglein, the Adjutant General of Minnesota, and Project Officer Major Adrian Beltrand, who directed the volunteer efforts of the Minnesota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

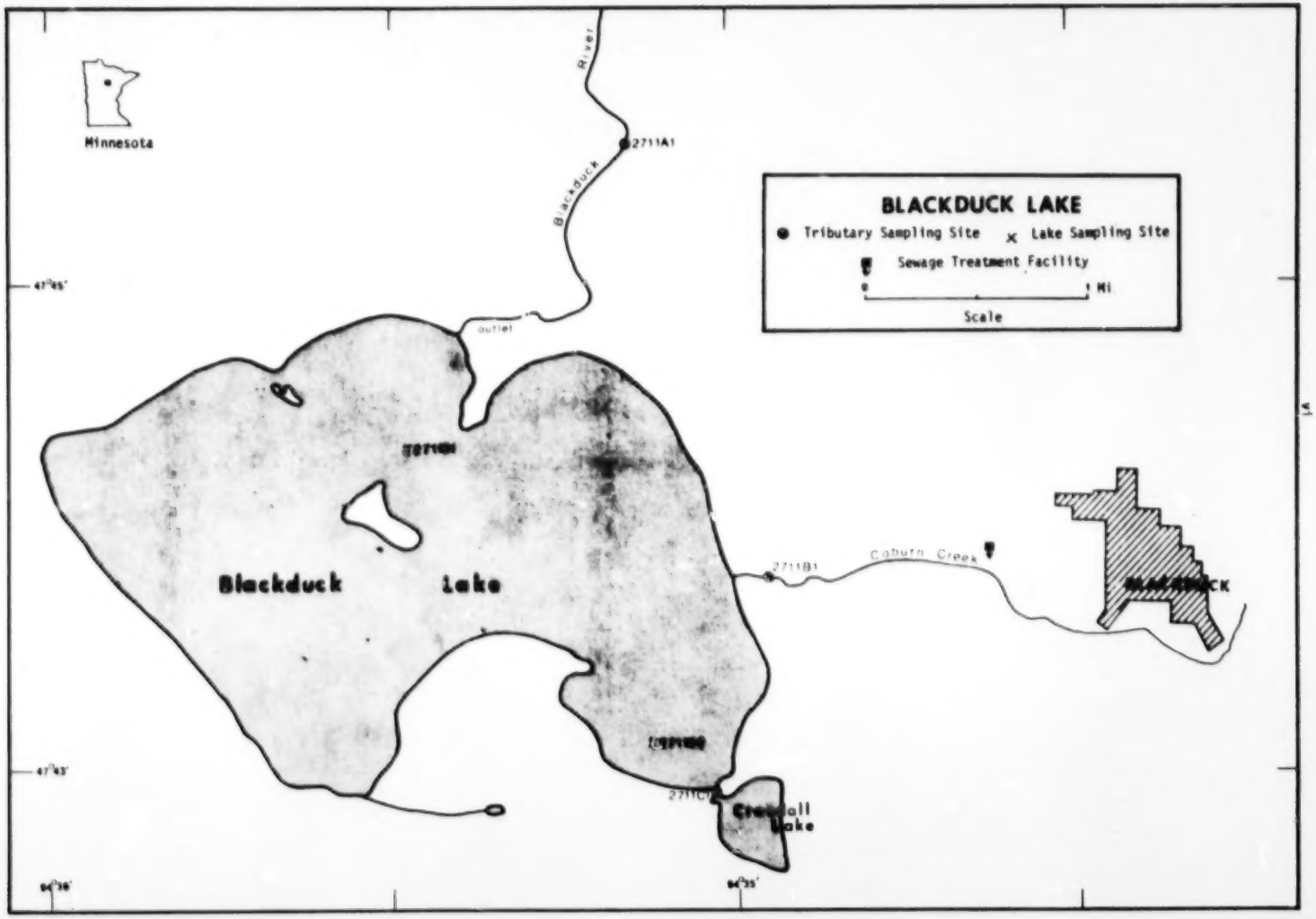
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF MINNESOTA

LAKE NAME	COUNTY
Albert Lea	Freeborn
Andrusia	Beltrami
Badger	Polk
Bartlett	Koochiching
Bear	Freeborn
Bemidji	Beltrami
Big	Stearns
Big Stone	Big Stone, MN; Roberts, Grant, SD
Birch	Cass
Blackduck	Beltrami
Blackhoof	Crow Wing
Budd	Martin
Buffalo	Wright
Calhoun	Henrepin
Carlos	Douglas
Carrigan	Wright
Cass	Beltrami, Cass
Clearwater	Wright, Stearns
Cokato	Wright
Cranberry	Crow Wing
Darling	Douglas
Elbow	St. Louis
Embarass	St. Louis
Fall	Lake
Forest	Washington
Green	Kandiyohi
Gull	Cass
Heron	Jackson
Leech	Cass
Le Homme Dieu	Douglas
Lily	Blue Earth
Little	Grant
Lost	St. Louis

LAKE NAME	COUNTY
Madison	Blue Earth
Malmedal	Pope
Mashkenode	St. Louis
McQuade	St. Louis
Minnetonka	Hennepin
Minnewaska	Pope
Mud	Itasca
Nest	Kandiyohi
Pelican	St. Louis
Pepin	Goodhue, Wabasha, MN; Pierce, Pepin, WI
Rabbit	Crow Wing
Sakatah	Le Sueur
Shagawa	St. Louis
Silver	McLeod
Six Mile	St. Louis
Spring	Washington, Dakota
St. Croix	Washington, MN; St. Croix, Pierce, WI
St. Louis Bay	St. Louis, MN; Douglas, WI
Superior Bay	St. Louis, MN; Douglas, WI
Swan	Itasca
Trace	Todd
Trout	Itasca
Wagonga	Kandiyohi
Wallmark	Chisago
White Bear	Washington
Winona	Douglas
Wolf	Beltrami, Hubbard
Woodcock	Kandiyohi
Zumbro	Olmstead, Wabasha


Minnesota
River
Blackduck
2711A1
BLACKDUCK LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0
1 Mi
Scale
47°45'
outlet
Blackduck
Lake
2711B1
Coburn Creek
47°43'
2711C1
Crandall
Lake
94°36'
94°35'

BLACKDUCK LAKE

STORET NO. 2711

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Blackduck Lake is eutrophic. Of the 60 Minnesota lakes sampled in the fall when essentially all were well-mixed, 22 had less mean total phosphorus, and 29 had less mean inorganic nitrogen. For the 80 lakes studied, 32% had greater Secchi disc transparency, and 50% had less mean chlorophyll a. Some depression of dissolved oxygen with depth was noted at station 1 in July, 1972.

Survey limnologists observed an algal bloom in progress in September, 1972. Reportedly, a permit was issued for the mechanical removal of aquatic plants in a small area of the lake in 1971 (Bonnema and Johnson, 1972).

B. Rate-Limiting Nutrient:

The results of the algal assay show that the sample was phosphorus limited. However, some change in nutrients from lake to assay occurred, and it is possible the lake was nitrogen limited at the time the assay sample was collected (N/P ratio = 13/1).

The lake data indicate nitrogen limitation at the other sampling times (N/P ratios were less than 8/1).

C. Nutrient Controllability:

During the sampling year, it is estimated that Blackduck Lake received a total phosphorus load a rate less than that proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 13) but more than a "permissible" (oligotrophic) rate. Of this load, it is estimated that the Village of Blackduck contributed about 42%. However, because of the estimations and assumptions necessary in the assessment of point and non-point loadings and loading rates, it is concluded that further studies are needed to determine nutrient controllability.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry*:

1. Surface area: 2,742 acres.
2. Mean depth: 14.8 feet.
3. Maximum depth: 28 feet.
4. Volume: 40,582 acre/feet.
5. Mean hydraulic retention time: 4.2 years.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area†	Mean flow†
Coburn Creek	4.5 mi^2	1.9 cfs
Crandall Lake outlet	4.6 mi^2	2.2 cfs
Minor tributaries & immediate drainage -	15.6 mi^2	9.2 cfs
Totals	24.7 mi^2	13.3 cfs

2. Outlet -

Blackduck River	29.0 mi^{2}††	13.3 cfs

C. Precipitation†††:

1. Year of sampling: 26.7 inches.
2. Mean annual: 25.3 inches.

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* DNR lake survey map (1949); mean depth by random-dot method.
† Drainage areas are accurate within ±5%; mean daily flows are accurate within ±10%; and ungaged flows are accurate within ±10 to 25% for drainage areas greater than 10 mi^2.
†† Includes are of lake.
††† See Working Paper No. 1, "Survey Methods".

III. LAKE WATER QUALITY SUMMARY

Blackduck Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page vi). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited from the two stations for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 15 feet at station 1, and 15 feet at station 2.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake was essentially well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (10/21/72)		
Temperature (Cent.)	4.3	4.3	4.3	4.4
Dissolved oxygen (mg/l)	10.4	11.0	11.2	11.2
Conductivity (μmhos)	240	240	240	240
pH (units)	7.8	7.9	7.9	7.9
Alkalinity (mg/l)	121	124	125	127
Total P (mg/l)	0.023	0.043	0.038	0.090
Dissolved P (mg/l)	0.009	0.016	0.013	0.025
NO_2 + NO_3 (mg/l)	0.150	0.160	0.160	0.170
Ammonia (mg/l)	0.040	0.053	0.050	0.070
		ALL VALUES		
Secchi disc (inches)	36	68	72	91

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
07/12/72	1. Melosira	989
	2. Dinobryon	989
	3. Fragilaria	314
	4. Cryptomonas	253
	5. Microcystis	157
	Other genera	555
	Total	3,257
09/08/72	1. Anabaena	1,120
	2. Microcystis	590
	3. Lyngbya	277
	4. Flagellates	265
	5. Chroococcus	241
	Other genera	748
	Total	3,241
10/21/72	1. Dinobryon	2,997
	2. Flagellates	708
	3. Cryptomonas	648
	4. Melosira	151
	5. Navicula	105
	Other genera	524
	Total	5,151

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
07/12/72	01	10.1
	02	14.1
09/08/72	01	9.8
	02	28.7
10/21/72	01	14.0
	02	10.6

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.016	0.272	2.1
0.005 P	0.021	0.272	4.6
0.010 P	0.026	0.272	6.4
0.020 P	0.036	0.272	7.2
0.050 P	0.066	0.272	7.8
0.050 P + 10.0 N	0.066	10.272	26.5
10.0 N	0.016	10.272	2.6

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Blackduck Lake was moderate at the time the sample was taken. Increased yields with increasing increments of phosphorus, and the lack of a significant increase in yield when

nitrogen only was added, indicates that phosphorus was limiting in the assay sample.

The lake data indicate nitrogen limitation in July (N/P ratio = 4/1) and September (N/P ratio = 7/1) but a borderline N/P ratio of 13/1 in October.

It is noted that there was about a 60 µg/l gain in inorganic nitrogen between sampling and the beginning of the assay. Had this change not occurred, the assay sample probably would have been nitrogen limited.

IV. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Minnesota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff month of April when two samples were collected, and the colder months when low flows prevented sampling at station A-1. Sampling was begun in October, 1972, and was completed in September, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Minnesota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean concentrations and mean flows, except for Coburn Creek at station B-1 where nutrient concentrations in at least 5 of the 13 samples were so high that it appears that most if not all of the stream flow at those times must have been effluent from the Village of Blackduck wastewater treatment plant (see station 2711B-1 in Appendix C). Accordingly, the nutrient loads attributed to Coburn Creek were estimated as follows. The total phosphorus load measured at the Crandall Lake outlet (C-1) amounted to 57 lbs P per square mile of drainage area for the sampling year. Now, the drainage area and flows of Coburn Creek are almost identical to those of the Crandall Lake outlet. Assuming the non-point nutrient sources in the two drainages are also similar, and assuming that 50% of the P load

of the drainage was sedimented and/or biologically assimilated in Crandall Lake, it is estimated that the non-point source load in Coburn Creek was 2 x 57 lbs/mi^2/yr or 114 lbs P/mi^2 for the sampling year (4.5 mi^2 x 114 = 513 lbs). Nitrogen was similarly estimated, but no loss was assumed in Crandall Lake.

Nutrient loadings for "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the mean concentrations in the Crandall Lake outlet at station C-1 and ZZ flows.

The Village of Blackduck declined participation in the Survey, and nutrient loads were estimated at 2.5 lbs P and 7.5 lbs N/capita/year.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (mgd)	Receiving Water
Blackduck	595*	Trickling filter	0.060**	Blackduck Lake

2. Known industrial - None

* Anonymous, 1973.
** Estimated at 100 gal/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Coburn Creek	510	14.5
Crandall Lake outlet	260	7.4
b. Minor tributaries & immediate drainage (non-point load) -	820	23.4
c. Known municipal -		
Blackduck	1,490	42.5
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	430	12.2
Total	3,510	100.0

2. Outputs -

Lake outlet - Blackduck River 1,580

3. Net annual P accumulation - 1,930 pounds

* See Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
Coburn Creek	6,440	10.0
Crandall Lake outlet	6,580	10.2
b. Minor tributaries & immediate drainage (non-point load) -	20,820	32.2
c. Known municipal -		
Blackduck	4,460	6.9
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	26,420	40.8
Total	64,720	100.0

2. Outputs -

Lake outlet - Blackduck River 35,480

3. Net annual N accumulation - 29,240 pounds

* See Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs $P/mi^2/yr$	lbs $N/mi^2/yr$
Crandall Lake outlet	57	1,430

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	1.3	0.7	23.6	10.7
grams/m^2/yr	0.14	0.08	2.6	1.2

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Blackduck Lake:

"Dangerous" (eutrophic rate)	0.20
"Permissible" (oligotrophic rate)	0.10

V. LITERATURE REVIEWED

Anonymous, 1973. Wastewater disposal facilities inventory. MPCA, Minneapolis.

Bonnema, Kenneth, and William G. Johnson, 1972. Control of aquatic vegetation, algae, leeches, and swimmer's itch in 1971. Dept. Nat. Resources, Minneapolis.

Schilling, Joel, 1974. Personal communication (lake map). MPCA, Minneapolis.

Vollenweider, Richard A., (in press). Input-output models. Schweiz. A. Hydrol.

VII. APPENDICES

APPENDIX A

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 2711 BLACKDUCK LAKE

TOTAL DRAINAGE AREA OF LAKE 29.00

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
271141	29.00	3.21	2.04	5.31	34.40	37.40	28.10	13.40	6.62	11.40	7.84	5.30	4.78	13.38
271141	4.48	0.31	0.16	0.91	6.29	5.09	4.44	1.90	0.67	1.54	0.80	0.48	0.49	1.92
2711C1	4.64	0.69	0.39	1.05	5.02	6.05	4.59	2.29	1.06	2.11	1.30	0.81	0.97	2.20
271177	19.90	3.90	2.31	5.20	22.60	24.10	19.50	8.97	4.05	7.48	4.88	3.19	4.18	9.19

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 29.00
SUM OF SUB-DRAINAGE AREAS = 29.02

TOTAL FLOW IN = 159.57
TOTAL FLOW OUT = 160.24

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
271141	10	72	7.18	14	4.50				
	11	72	5.00	5	5.00				
	12	72	7.19	10	7.80				
	1	73	3.53	20	3.10				
	2	73	2.24	18	2.20				
	3	73	14.58	17	44.00				
	4	73	4.82	1	13.00	14	1.70		
	5	73	4.86	19	9.70				
	6		3.37	3	4.70				
	7	73	2.62	8	3.00				
	8	73	3.57	11	6.70				
	9	73	74.10	16	44.00				
271141	10	72	0.71	14	1.00				
	11	72	0.46	5	0.50				
	12	72	0.74	10	0.70				
	1	73	0.34	20	0.30				
	2	73	0.17	18	0.20				
	3	73	2.48	17	7.50				
	4	73	0.88	1	2.40	14	0.30		
	5	73	0.44	19	1.30				
	6	73	0.53	3	0.70				
	7	73	0.36	8	0.41				
	8	73	1.37	11	2.60				
	9	73	10.50	16	6.50				

TRIBUTARY FLOW INFORMATION FOR MINNESOTA 10/30/74

LAKE CODE 2711 BLACKDUCK LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2711C1	10	72	1.19	14	1.60				
	11	72	0.76	5	0.80				
	12	72	1.46	10	1.40				
	1	73	0.75	20	0.70				
	2	73	0.43	18	0.40				
	3	73	2.47	17	8.60				
	4	73	0.70	1	1.90	14	0.20		
	5	73	0.79	19	1.80				
	6	73	0.55	3	0.80				
	7	73	0.44	8	0.51				
	8	73	2.17	11	1.80				
	9	73	14.59	16	9.00				
271127	10	72	4.47	14	5.90				
	11	72	3.91	5	3.00				
	12	72	6.24	10	6.10				
	1	73	4.18						
	2	73	2.35	18	2.40				
	3	73	14.23	17	43.00				
	4	73	3.16	1	8.80	14	1.10		
	5	73	3.13	19	6.20				
	6	73	2.34	3	3.20				
	7	73	1.78	8	2.00				
	8	73	8.40	11	16.00				
	9	73	21.20	16	38.00				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/10/30

271101
47 44 20.0 094 37 45.0
BLACKDUCK LAKE
27 MINNESOTA

11EPALES
4

2111202
0014 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/12	13 35	0000			72							
	13 35	0004	22.7	10.2		260	7.20	130	0.030	0.050	0.025	0.015
	13 35	0015	21.1	6.4		260	7.40	131	0.030	0.050	0.034	0.024
72/09/08	13 55	0000	16.8		60	243	8.15	128	0.140	0.100	0.049	0.023
	13 55	0004	16.5	6.3		242	8.23	128	0.140	0.080	0.043	0.019
	13 55	0010	16.3	6.6		242	8.23	129	0.140	0.070	0.046	0.016
72/10/21	16 10	0000			91	240	7.90	125	0.150	0.050	0.023	0.009
	16 10	0004	4.3	11.2		240	7.90	123	0.150	0.040	0.025	0.012
	16 10	0015	4.3	11.2		240	7.90	121	0.160	0.070	0.090	0.014

19

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/12	13 35	0000	10.1J
72/09/08	13 55	0000	9.8J
72/10/21	16 10	0000	14.0J

J VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/10/30

271102
47 43 30.0 094 36 00.0
BLACKDUCK LAKE
27 MINNESOTA

11EPALES 2111202
4 0015 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/07/12	13 55	0000			72							
	13 55	0004	21.7	6.4		245	7.70	130	0.040	0.060	0.042	0.019
	13 55	0015	21.5	8.2		250	7.60	130	0.030	0.040	0.043	0.020
72/09/08	14 10	0000	17.3		36	240	8.70	128	0.060	0.080	0.085	0.034
	14 10	0004	17.1	10.6		240	8.70	128	0.060	0.080	0.096	0.031
	14 10	0010	16.9	10.1		240	8.65	129	0.060	0.070	0.086	0.030
72/10/21	16 30	0000			75	240	7.80	125	0.170	0.060	0.036	0.013
	16 30	0004	4.4	10.4		240	7.80	125	0.170	0.050	0.047	0.025
	16 30	0008	4.4	11.2		240	7.90	127	0.160	0.050	0.040	0.022

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/07/12	13 55	0000	14.1J
72/09/08	14 10	0000	28.7J
72/10/21	16 30	0000	10.9J

J VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY DATA

STORET RETRIEVAL DATE 74/10/10

27111A1 LS27111A1
47 45 30.0 094 36 00.0
BLACKDUCK RIVER
27 CO #4. SHEET #1
O/BLACKDUCK LAKE
CO HWY 32 BRDG 2.5 MI NW OFBLACKDUCK
11FBALFS 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/11/05	13 05		0.023	0.720	0.035	0.00K	0.050
73/03/17	11 25		0.294	1.000	0.054	0.031	0.050
73/04/01	16 00		0.105	2.100	0.038	0.013	0.115
73/04/14	11 20		0.010K	2.400	0.022	0.005K	0.035
73/05/19	12 25		0.010K	0.810	0.016	0.009	0.025
73/06/03	13 45		0.014	1.650	0.014	0.017	0.077
73/07/08	13 20		0.044	0.960	0.050	0.048	0.070
73/08/11	11 10		0.036	1.000	0.026	0.022	0.050
73/09/16	12 00		0.022	1.500	0.056	0.019	0.065

K VALUE KNOWN TO BE LESS
THAN INDICATED

22

STORET RETRIEVAL DATE 74/12/30

271181 LS271181
47 43 00.0 094 35 10.0
COBURN CREEK
27 CO #4, SHEET #1
O/BLACKDUCK LAKE
CO HWY 30 XING
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3&NO2 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	09 10		1.240	3.000	2.200	0.042	0.790
72/11/05	14 30		0.450	8.100	2.500	1.160	16.000
72/12/10	13 50		0.025		13.650	7.425	8.100
73/01/20	13 30		0.0104	14.200	10.500	4.350	4.720
73/02/14	15 15		0.045	14.000	14.000	5.500	7.000
73/03/17	12 45		0.530	2.100	1.340	0.260	0.375
73/04/01	16 30		0.154	1.940	0.900	0.370	0.550
73/04/14	12 50		0.163	3.600	0.940	0.580	0.630
73/05/19	13 15		0.210	5.900	3.400	2.300	2.700
73/06/03	14 10		0.034	10.500	7.400	4.200	5.200
73/07/09	13 40		0.035	7.300	4.400	2.700	2.950
73/08/11	12 05		0.580	7.450	0.185	0.083	3.100
73/09/16	12 45		0.0104	6.800	0.034	0.150	0.340

K, VALUE KNOWN TO BE LESS THAN INDICATED

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STORET RETRIEVAL DATE 74/10/30

2711C1 LS2711C1
47 43 00.0 094 35 30.0
CRANDALL/BLACKDUCK LAKES COMM
27 CO #4 SHEET #1
T/BLACKDUCK LAKE
CO HWY 35 BRDG
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00623 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/10/14	09 00		0.194	1.225	0.075	0.005K	0.066
72/11/05	14 37		0.017		0.056	0.005K	0.031
72/12/10	14 00		0.130	1.260	0.076	0.007	0.040
73/01/20	13 35		0.160	1.200	0.205	0.032	0.065
73/02/12	15 20		0.147	1.760	0.220	0.039	0.080
73/03/17	12 52		0.059	1.600	0.115	0.018	0.050
73/04/01	16 35		0.010K	1.480	0.026	0.006	0.045
73/04/14	13 15		0.017	1.320	0.019	0.006	0.035
73/05/10	13 20		0.010K	2.600	0.075	0.090	0.185
73/06/03	14 20		0.010K	1.300	0.038	0.008	0.020
73/07/04	13 45		0.010K	1.100	0.030	0.018	0.030
73/08/11	12 10		0.010K	1.150	0.024	0.016	0.060
73/09/16	12 50		0.010K	1.700	0.030	0.027	0.090

K VALUE KNOWN TO BE LESS THAN INDICATED

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